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OPTIMISING PERINATAL OUTCOME IN FETAL GROWTH RESTRICTION USING DOPPLER VELOCIMETRY

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BONAFIDE CERTIFICATE

This is to certify that this dissertation in **"OPTIMISING PERINATAL OUTCOME IN FETAL GROWTH RESTRICTION USING DOPPLER VELOCIMETRY"** is the work done by **Dr.SUNITHA SOUNDARAPANDIAN,** at the Institute of Obstetrics & Gynaecology, Government Hospital for Women and Children MMC Chennai under the guidance of **Prof. Anjalakshi Chandrasekar, M.D., D.G.O., Ph.D.,** during the period 2004 - 2007.

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INTRODUCTION

Ante partum fetal surveillance is the corner stone of preventive obstetric management aimed at reducing maternal and perinatal mortality and morbidity. Ante partum detection of fetus at risk of death or compromise in utero remains the major challenge in modern obstetrics. Specific and accurate methods for detection of fetus at risk can result in early appropriate intervention and hence reduce fetal loss. Diagnostic ultrasound is the main stay in the evaluation and management of obstetric patients. Antenatal test of fetal well being depends indirectly on changes in fetal physiology, an aspect of fetus, which until recently, has been relatively inaccessible to study. There has been a paucity of techniques to measure the placental function - the critical organ through which the transfer of nutrients occur. Fetal growth and development rely on normal uteroplacental and fetoplacental circulation to supply oxygen and nutrients from the maternal circulation. New technologies have now become available in the clinical assessment of placental function. Doppler ultrasound offers a non - invasive evaluation of the feto-placental circulation and can identify placental circulatory failure. There are specific abnormalities in Doppler parameters in asymmetric intrauterine growth retardation, which occurs as a result of utero - placental insufficiency . Hence doppler ultrasound plays a key role in antenatal fetal surveillance of high risk pregnancies like evaluation of growth restricted fetuses.

Fetal growth restriction or **Intrauterine growth restriction** is defined as estimated fetal weight at or below the 10th percentile for gestational age. However, 70% of fetuses with estimated fetal weight below the 10th percentile

are just constitutionally small. This means that they have lower anthropometric measurements and birth weight but their rate of growth is normal. They don't face any of the other complications faced by FGR babies. So, a better definition of FGR is failure of the fetus to achieve its inherent genetic growth potential in utero (Rajan R. 2001)[4]. This leads to a reduction in size or number of cells, in the fetus. So, these fetuses, apart from having a low birth weight, also have an increased perinatal mortality and morbidity. This is due to complications like malformations, hypoxia and acidosis in the fetus; hypoglycemia, hypothermia, meconium aspiration, in the neonate; long term complications like seizures, cerebral palsy, lower IQ and behavioural problems.

Diagnosis of IUGR is based on B-mode ultrasound. Estimation of fetal weight in utero using multiple ultrasound parameters remains the mainstay in screening for FGR. Use of various fetal morphometric ratios and/or measurements of other fetal parameters may provide additional useful information. Serial evaluation to assess interval growth may be necessary to clarify the diagnosis.

Doppler velocimetry has poor sensitivity in detecting IUGR, whereas it is helpful in assessing the hemodyanmic state. Doppler indices change if the fetus is compromised due to hypoxemia, secondary to uteroplacental insufficiency.

Doppler flow velocimetry, particularly of the middle cerebral and umbilical arteries is an earlier predictor of hypoxemia, when compared to BPP or NST. Ductus venosus alteration is an accurate predictor for acidemia.

The relationship between the size of fetal abdominal circumference and fetal head is used to characterize the pattern of FGR as being either symmetric or asymmetric. Symmetric IUGR refers to a growth pattern in which the growth of both the fetal abdomen and head are decreased proportionally. Asymmetric IUGR refers to the growth-retarded fetus in which a disproportionate decrease in the size of fetal abdomen with respect to the fetal head is seen.

Symmetric IUGR may result from an early insult such as genetic or infective pathology that impairs fetal cellular hyperplasia and therefore causes a proportionate decrease in size of all fetal organs. By contrast, asymmetric IUGR may be caused by a later insult that impairs cellular hypertrophy, causes a disproportionate decrease in the size of fetal abdomen in relation to that of the fetal head. Progressive uteroplacental insufficiency may be associated with this asymmetric growth pattern.

Nearly 70% of patients with IUGR may be classified as having an asymmetrical growth pattern. These cases may be at greater risk for perinatal hypoxia and neonatal hypoglycemia, hypothermia However, their long-term prognosis with appropriate management is good.

Symmetric IUGR results from an early insult and is characterized by a long period of subnormal growth. These infants usually do not have perinatal hypoxia, but they are at risk of long-term neurodevelopmental dysfunction, resulting from a deficit in the total number of brain cells.

This study highlights the complications faced by growth restricted babies and the ease with which these problems can be predicted and to some extent, prevented with Doppler evaluation of fetoplacental vasculature.

AIMS AND OBJECTIVES

1. To detect any abnormalities in fetoplacental unit and fetal circulation in IUGR.

2. To identify the hypoxemic fetus & time the delivery before the occurrence of acidemia.

3. To correlate the occurrence of adverse perinatal outcome with degree of abnormality in doppler indices.

REVIEW OF LITERATURE

To avoid undue alarm in patients, to whom the term "Retardation" implies abnormal mental function, the term "Fetal growth restriction" is now preferred. About 3-10% of infants are growth restricted (Divon and HSU, 1992)[1].

In 1961, Warkany and co-workers[2] reported normal values for infant weight, lengths and head circumferences which served to define fetal growth restriction. In 1963, Gruenwald[3] reported that approximately one third of low birth weight infants were mature and that their small size could be explained by "chronic placental insufficiency".

In 1963, Lubchenco and coworkers[5] from Denver published detailed comparisons of gestational ages to birth weights in an effort to derive norms for expected fetal size and therefore growth at a given gestational week. Battagalia and Lubchenco (1967)[6] classified small for gestational age infants as those whose weights were below the 10th percentile for their gestational age. The neonatal mortality rate of a small for gestational age infant born at 38 weeks was 1 percent compared with 0.2% in those with appropriate birth weights. Seeds and Peng (1998)[7] concluded that the threshold for impaired growth based upon the risk of fetal death should be set even higher at the 15th birth weight percentile.

Manning and Hohler (1991)[8] and Gardosi (1992)[9] concluded that 25-60% of infants conventionally diagnosed to be small for gestational age were in fact appropriately grown when determinants of birth weight such as maternal ethnic group, parity & weight are considered.

A definition based upon birth weight below the fifth percentile was also proposed by Seeds (1984)[10]. Usher and McLean (1969)[11] proposed that fetal growth standards should be based on mean values with normal limits defined by $\pm$ 2 standard deviations because this definition would limit small for gestational age infants to 3% of births instead of 10% with use of the 10th percentile. From a clinical standpoint this definition appears to be most meaningful. This is because most poor outcomes are in those infants with birth weights below the third percentile.

In a study of 122,754 pregnancies delivered at Parkland Hospital, Mclntire and Colleagues (1999)[12] found that mortality and morbidity were significantly increased among infants born at term only when their birth weights were at or below the third percentile for their gestational age.

Relationship between birth weight percentile and perinatal mortality & morbidity is observed on 1560 SGA fetuses. A progressive increase in both mortality and morbidity is observed as birth weight percentile falls. (Manning 1995)[13].

Owen and Colleagues in 1997[14] and Owen and Khan in 1998[15] reported that reduction in the rate of velocity of fetal growth detected by serial ultrasonic fetal anthropometry is related to caesarean delivery for fetal distress and significant fetal growth restriction.

Fetal growth restriction is associated with substantial perinatal mortality and morbidity. Incidence of fetal demise, birth asphyxia, meconium aspiration, neonatal hypoglycemia and hypothermia are all increased, as is the prevalence

of abnormal neurological development (Paz 1995[16], Piper 1996[17]). Postnatal growth and development of growth - restricted fetuses depends on the cause of restriction, nutrition in infancy and social environment (Kliegman 1997[18]). Infants with growth restriction due to congenital, viral infection, chromosomal or maternal constitutional factors remain small throughout life. Those infants with in utero growth restriction due to placental insufficiency will often have catch up growth after birth and approach their inherited growth potential when provided with an optimal environment.

Campbell and Thorns (1977)[19] described the use of the sonographic head to abdomen circumference ratio (HC/AC) to differentiate fetuses into subtypes - "Symmetrical" meaning proportionately small and "Asymmetrical" meaning those with disproportionately lagging abdominal growth. 70% of the fetuses with a HC/AC ratio above the 95th percentile were termed asymmetrical. Even though similar gene realization exists, those with aneuploidy typically had disproportionately large head size (Nicolaides 1991)[20].

Similarly most preterm infants with growth restriction due to preeclampsia and associated uteroplacental insufficiency demonstrate a symmetrical pattern of growth impairment rather than the hypothesized asymmetrical pattern (Salafia 1995)[21].

Dash and Colleagues (2000)[22] analyzed HC/AC ratio. Only 20% of growth restricted fetuses were at increased risk for intrapartum and neonatal complications. Symmetrically growth restricted fetuses with birth weight less than 10th percentile were not at increased risk of adverse outcomes.

Early establishment of gestational age, attention to maternal weight gain, careful measurement of uterine fundal growth throughout pregnancy will serve to identify many cases of abnormal fetal growth in women without risk factors. Identification of risk factors, including a previously growth restricted fetus should raise the possibility of recurrence during the current pregnancy in women with significant risk factors, for whom serial sonography is considered. Definitive diagnosis, however, usually cannot be made until delivery.

Identification of the inappropriately growing fetus remains a challenge; such identification is not always possible even in the nursery. Carefully performed serial fundal height measurements throughout gestation are a simple, safe, inexpensive and reasonably accurate screening method to detect many small for gestational age fetuses (Gardosi and Francis 1999)[23] But its principal drawback is imprecision. Jenson and Larsen (1991)[24] and Walraven (1995)[25] found that symphysis to fundal measurements helped to correctly identify only 40% of such infants. Thus, small for age infants are either over-looked or over-diagnosed. Despite this, carefully measured fundal height is still considered as a simple screening method.

The method to measure fundal height by using a measuring tape was first reported by Jimenez and colleagues (1983)[26]. Between 18 and 30 weeks the uterine fundal height in centimeters coincides with the weeks of gestation. If the measurement is more or less than 2-3cm from the expected height, inappropriate fetal growth may be suspected.

Routine screening incorporates an ultrasound examination at 16-20 weeks to establish gestational age and rule out visible anomalies, and then

follow-up imaging at 32-34 weeks to evaluate fetal growth .Combining head, abdomen and femur dimensions should in theory enhance the accuracy of predictions of fetal size. But any potential improvement is apparently lost by the cumulative error inherent in measurement of each individual fetal dimension. Thus most experts have accepted abdominal circumference measurement as the most reliable index of fetal size (Manning et al[13] 1995; Smith 1997[27], Snijders & Nicolaides 1994[28]). In these studies, estimated fetal weight calculated with abdominal circumference measurement was almost always within 10% of the actual birth weight.

The use of ultrasound for detection of fetal growth restriction does not preclude missed diagnoses. Dash and Colleagues (2000)[22] studied 8400 live births at Parkland hospital of those women who had ante partum ultrasound within 4 weeks of delivery. Although 70% of growth restricted fetuses were detected, 30% were missed.

Risk Factors of IUGR

Constitutionally small mothers

Small women typically have smaller babies. Data from a longitudinal study of all births during one week in 1958 in England, Wales and Scotland indicate that there are intergenerational effects on birth weight that are transmitted through the maternal line (Emanuel 1992)[29]. Klebanoff (1997)[30] reported that reduced intrauterine growth of the mother is a risk factor for reduced intrauterine growth of her children. Brooks and co-authors (1995)[31] analyzed 62 births where the relative influence of the donor versus the recipient on birth weight, after ovum donation, was examined. They concluded that the

environment provided by the mother was more important that her genetic contribution to birth weight.

Poor maternal weight gain and nutrition

In the women of average or low weight, lack of weight gain throughout pregnancy may be associated with fetal growth restriction (Simpson1975)[32]. Lack of weight gain in the second trimester strongly correlates with decreased birth weight (Abrams and Selvin 1995)[33].

Social Deprivation

Williams (2001)[34] wrote "the social condition of the mother and the comforts by which she is surrounded also exert a marked influence upon child's weight, heavier children being more common in the upper walks of life".

Fetal Infections

Viral, bacterial, protozoan and spirochetal infections are implicated in upto 5% of cases of fetal growth restriction (Klein and Remington 1995)[35] - Rubella, Cytomegalovirus virus, Hepatitis A, Hepatitis B, Listeriosis, Tuberculosis, Syphilis, Toxoplasmosis and congenital Malaria.

Congenital malformations

With major structural anomalies, 22% had accompanying growth restriction (Khoury 1988)[36]. More severe the malformation, the more likely the fetus is to be small for gestational age.

Chromosomal abnormalities

Placental insufficiency, primary abnormal cellular growth and differentiation may contribute to the significant degree of fetal growth restriction associated with karyotype abnormalities.

Prominent postnatal growth failure occurs in trisomy 21, whereas fetal growth restriction is generally mild (Thelander, Pryor 1966)[37]. Trisomy 18 is associated with severe fetal growth restriction.

Trisomy 16 is the most common trisomy in spontaneous abortions and is lethal to the fetus in non-mosaic state (Lindor 1993)[38] Patches of trisomy 16 in the placenta called "confined placental mosaicism" leads to placental insufficiency & may account for many cases of previously unexplained fetal growth restriction (Kalousek 1993)[39]. Here chromosome abnormality is confined to placenta. Inherited syndromes such as osteogenesis imperfecta and various chondrodystrophies are associated with fetal growth restriction.

Chemical teratogens

Anticonvulsants such as phenytoin and trimethadione may produce specific and characteristic syndromes that include fetal growth restriction (Hanson 1976)[40]. Cigarette smoking causes growth restriction as well as preterm delivery in a direct relationship with the number of cigarettes smoked (Cliver 1995)[41]. Narcotics decrease maternal food intake and fetal cell number. Alcohol acts in a linear dose related fashion.

Vascular disease

Chronic vascular disease, especially when complicated by superimposed pre-eclampsia, commonly causes growth restriction. Pre-eclampsia, by itself may cause fetal growth failure, when the onset is before 37 weeks (Xiong 1999)[42].

Renal disease may be accompanied by restricted fetal growth (Stettlerand Cunningham 1992)[43].

Chronic hypoxia

Fetuses of women who reside at high altitude usually weigh less than those born to women who live at a lower altitude. Fetuses of women with cyanotic congenital heart diseases are frequently severely growth restricted (Patton 1990)[44].

Maternal anemia

Sickle cell anemia or other inherited anemias associated with serious maternal disease cause fetal growth restriction.

Deficient total maternal blood volume early in pregnancy is linked to fetal growth restriction (Duvekot 1995)[45].

Placental and cord abnormalities

Chronic partial placental separation, extensive infarction, chorioangioma, circumvallate placenta, placenta previa, marginal insertion of the cord and velamentous insertions are all accompanied by growth restricted

fetuses. Many cases of IUGR occur in pregnancies with apparently normal fetuses with grossly normal placentas. Growth failure in these cases is presumed to be due to uteroplacental insufficiency. Women with otherwise unexplained FGR demonstrated a four-fold reduction in uteroplacental blood flow compared with normally grown fetuses (Lunell and Nylund 1992)[46]. Similar reductions were also seen in growth restricted fetuses with congenital malformations suggesting that maternal blood flow might in part be regulated by the fetus (Howard 1987[47]). Uteroplacental blood flow is also reduced in women with pre-eclampsia compared with normotensive women.

Multiple fetuses

Twin pregnancy is more likely to be complicated by diminished growth of one or both fetuses compared with normal singletons. Growth restriction has been reported in 10-50% of twins (Hill 1994)[48].

Antiphospholipid antibody syndrome

Two classes of antibodies, associated with fetal growth restriction, are anticardiolipin antibodies and lupus anticoagulant (Lockwood and Rand 1994)[49]. Pathophysiological mechanism in the fetus appears to be caused by maternal platelet aggregation and placental thrombosis.

Doppler Velocimetry

Basic principles

Doppler shift is a physical principle that states that when a source of light or sound wave is moving relative to an observer, observer detects a shift

in the wave frequency. Thus, when sound waves strike a moving target, the frequency of sound waves reflected back is shifted proportionate to the velocity and direction of the moving target. As the magnitude and direction of the frequency shift depend on the relative motion of the moving target, their velocity and direction can be determined (Williams, 2001)[34].

Doppler principle is used to determine the volume and rate of blood flow through maternal and fetal vessels. Here, the sound source is ultrasound transducer & moving targets are the red blood cells flowing through the circulation. When the distance between the source of sound and the reflector changes, there is a change in the frequency of the reflected echo-Doppler shift - which is converted by the machine to 3 different kinds of output, namely;

- Audio output on a loudspeaker-characteristic for each vessel-we can identify each vessel easily
- Spectral waveform-is also unique to each vessel. The pattern of the waveform depends largely on the distal vascular impedance and the compliance of the vessel.
- Colour doppler- used to code the blood flow in a portion of the vessel. Flow toward the transducer is shown as red and away from the transducer as blue.

Duplex ultrasound: B- mode and the spectral waveform displayed together are called duplex mode.

Doppler is generally used in two ways to estimate circulatory hemodynamics:

1. Direct measurement of volume of blood flow.
2. Indirect estimation of flow velocity using wave form analysis.

Blood flow measurement

Errors in direct measurement of the volume of blood flow have led to the development of several indirect indices of flow, which are independent of the angle of insonation and do not require measurement of the diameter of the vessel.

Colour Doppler is switched on to locate the vessel, then the pulsed Doppler sample volume is placed on the vessel and optimal spectral waveforms are obtained.

Specific measurements like peak systolic velocity (PSV) and the end diastolic velocity (EDV) are made from this optimal spectral waveform, and the various ratios are computed. If the peak systolic velocity is called "S" and the end diastolic velocity is called "D" the various ratios calculated are

(1) S/D ratio

(2) Resistance Index (RI) = S-D/S

(3) Pulsatility Index (PI) = S-D / Mean

Mean velocity is the average of all the velocities that are present during one cardiac cycle and is computed by the machine. Of these, the PI, according to Gosling and King (1975)[50] would seem to be best suited for practical purposes, as it increase linearly with increasing flow impedance.

All ultrasound equipment will have measurement facility and in most equipment, an automatic trace of the waveform is made as the waveform is being generated in real time.

Uterine and arcuate arteries

Uterine artery is a branch of the internal iliac artery,arising close to the bifurcation. Uterine blood flow increase from 50ml/mt shortly after conception to 500 to 750 ml/mt by term..Doppler waveforms of the uterine artery undergo gradual changes in their charecterestics with advancing gestation.

- A sharp systolic peak and forward flow in diastole
- Upto 16 wks of gestation an early diastolic notch can be noticed(represents the presence of elastic coat in the spiral arteries)
- Beyond this period ,the notch disappears (18-23wks)(due to trophoblastic invasion of spiral arterioles)
- Diastolic velocity increases and thus the indices decrease as term approaches(SieroszewskiP 2005)[51]
- Failure of the pattern to appear or the presence of a notch in the waveform at end systole after mid trimester has been reported with fetal growth restriction(Schulman 1986)[52]
- Women with abnormal uterine artery Doppler indices and persistence of notch are at high risk of obstetric comlications (Papageorghiou, Nicolaides 2002)[53]

- Women with normal uterine artery doppler have low risk of developing obstetric complications related to placental dysfunction.

- Following a positive test the risk of developing preeclampsia is increased by 6 times and the risk of developing IUGR is increased by 3 times (Papageorghiou 2002)[53]

- However a meta analysis of observational studies on uterine artery Doppler in predicting IUGR&preeclampsia,showed that the likelihood ratios did not alter the pre test probabilities of IUGR and preeclampsia in a great way-Hence the utility of doppler as a screening test for pre-eclampsia and IUGR is guarded(Chien 2000)[54]

Umbilical artery

Anatomy

The umbilical arteries arise from the internal iliac arteries of the fetus and course along the umbilical cord to reach the placenta. Intraplacentally, they branch into primary, secondary and tertiary stem villous vessels, which form the placental vascular bed. As pregnancy advances, increase in tertiary stem villi leads to steady decrease in vascular bed resistance.

Normal umbilical artery waveforms

- In early weeks of gestation the umbilical artery reveals absent diastolic flow.

- Beyond 15 weeks of gestation, diastolic flow is consistently seen.

- As pregnancy advances, there is an increase in diastolic flow and the RI is low.

Abnormal umbilical artery waveforms

- Seen when 70% of the tertiary villi are affected (IUGR is seen even when 40% are affected).This is the reason why umbilical artery doppler cannot be used as a screening test for IUGR.

- 3 types of abnormalities are seen(indication of increasing resistance which correlates with fetal hypoxia)

. a) Low diastolic flow (high resistance)

b) Absent diastolic flow

c) Reversed flow in diastole

A meta-analysis of all randomized studies of doppler ultrasound of umbilical artery in IUGR by Alfirevic and Neilson in 1995[55] concluded that all women with suspicion of IUGR should have access to Doppler of the umbilical artery.

Elevated PI, RI or S/D ratios in umbilical and uterine arteries have been correlated to morphological changes in placental vascular bed (Olofsson et al 1993)[56].

Gudmundsson and Marshal in 1991[57] showed that ARED in umbilical artery Doppler, 96% of these fetuses showed hypoxia or asphyxia at delivery. These results indicate that umbilical artery Doppler has the capacity to find

those SGA fetuses that are truly at risk of developing asphyxia and therefore need surveillance. Additional information may be found in the other vascular beds.

Cerebral blood flow

- Doppler evaluation of blood flow through cerebral vessels allows detection of altered cerebral circulation before hypoxemia significant enough to change the fetal heart rate has occurred

- Middle cerebral artery is the most accessible vessel and has been reported to demonstrate reduction in the pulsatility index at the onset of hypoxemia (Wladimiroft 1991)[58].

- Chandran and colleagues (1993)[59] compared middle cerebral artery pulsatility indices with fetal heart rate analysis in 27 growth restricted fetuses, and found that Doppler was a more sensitive predictor of hypoxemia at birth than fetal heart rate testing but had lower specificity.

- Unlike the uterine and umbilical vascular beds which constantly change with advancing gestational age, the MCA vascular bed resistance is almost constant throughout pregnancy (the RI is 0.75-0.85).

- This is due to the fact that the intracerebral flow is controlled by an auto regulatory mechanism which responds to fetal oxygen saturation.

- Reduction in the oxygen saturation (hypoxemia) causes dilatation of the intracerebral vessels, leading to increased flow or decreased cerebral resistance (Vyas, Nicolaides et al 1990)[60].

- Cephalisation of flow is associated with redistribution of cardiac output in favour of the left ventricle preferentially perfusing the brain and myocardium with oxygenated blood (Al-ghazali et al 1987)[61]. This occurs during hypoxia and is reflected in MCA as increased diastolic flow with reduced RI.

- With increasing hypoxia, the fetus can become acidemic which results in cerebral edema. This causes increased cerebral resistance and diastolic flow in the MCA may be reduced or even absent. This indicates poor prognosis..

- Demonstration of cephalisation enhances the positive predictive value of an elevated umbilical artery Doppler index for hypoxemia.

- This brain sparing effect has been evaluated in animal studies and confirmed in human studies(Malcus et Al[62] 1991,Mari and Deter 1992)[63]

- Further it pre-dates the appearance of late decelerations on the CTG strip of IUGR fetus by an average of two weeks (Arduini et al 1992)[64].

Cerebroplacental ratio

- A ratio of the resistances in the umbilical artery and the MCA can be compared for better interpretation of fetal hypoxia.

- In normal fetuses, the placental vascular resistance decreases as pregnancy advances, whereas the MCA resistance is constant.

- The RI of MCA / RI of Umb. A is more than 1.

- In cerebral redistribution, the MCA RI decreases and the umbilical artery increases, leading to cerebroplacental ratio of less than 1, indicating fetal hypoxia.

- Clinical reports suggest that ratios between cerebral and umbilical arteries have the best predictive values for adverse outcome in growth restricted fetuses.

- Gramellini et al 1992[65] found the diagnostic accuracy for the cerebro placental ratio to be 90% for predicting adverse outcome in IUGR, compared to 83% and 79% for umbilical artery and MCA alone respectively in the same study.

Ductus venosus

In venous Doppler, the first and most important conduit in fetal circulation is the ductus venosus.

- It is a narrow vessel which arises from the transverse portion of the left portal vein and is connected to the IVC.

- It is funnel shaped and has a muscular coat.

- 45% of the blood from the umbilical vein enters the right atrium via the IVC through the ductus venosus, bypassing the liver.

- The ductus venosus waveform has a typical M pattern

- The audio signals of the ductus venosus have a typical rhythmic musical quality which is very characteristic.

- Doppler of the ductus is only indicated if the umbilical artery and MCA are abnormal.

- Cardiac deterioration is associated with acidemia. Here venous studies are informative (Baschat et al 2000)[66].

- Venous indices reflect ventricular function and to a certain extent cardiac overload. Prolonged hypoxemia leads to hypoxemic cardiomyopathy, ventricular dysfunction, and a fall in cardiac output. As cardiac output declines, central venous pressure rises causing increased reversed flow during atrial systole. As the severity intensifies, direction of blood flow in the ductus venous reverses during atrial contraction causing pulsatile umbilical venous flow. Its development is associated with decreased fetoplacental perfusion and intra uterine fetal death (Gudmunsson et al 1993[76]). It is in these late stages, reversal of diastolic flow in umbilical artery is observed.

- An abnormal ductus waveform is recognized when there is a dip in the A wave, i.e. when the forward flow during atrial systole is less. This causes an increase in PI.

- Reversal of A wave indicates cardiac decompensation and acidemia.

- Growth restricted fetuses with abnormal venous flow have worse perinatal outcome compared to those where flow abnormality is confined to umbilical or MCA (Baschat et al 2000)[66].

- In a majority of severely growth restricted fetuses, sequential deterioration of arterial and venous flows precedes biophysical score deterioration.

- Thus, the typical progression begins with increased resistance in the umbilical artery followed by decreased resistance in the middle cerebral artery and is completed with the development of abnormal venous waveforms as cardiac function deteriorates.

- Adding serial doppler of umbilical artery MCA and DV to IUGR surveillance will enhance the performance of biophysical score in detecting fetal compromise and optimizing the time of intervention (Baschat et al 2001)[67].

MATERIALS AND METHODS

This study was conducted jointly at the Institute of Obstetrics and Gynecology and Barnard Institute of Radiology, Chennai both coming under the Madras Medical College, Chennai. Two hundred documented IUGR cases confirmed by clinical evaluation and serial ultrasound biometry were selected for the study and it was done on singleton pregnant women with well-documented period of gestation beyond 34 weeks. Known congenital anomalies were excluded from the study.

The machine used for Doppler was an Aloka 3500 color Doppler machine with a 3.5 to 5 MHz curvilinear probe.

Name, Age, Unit, Registration number and Address of the patients were noted. Detailed obstetric history including the history of pregnancy induced hypertension; gestational diabetes and chronic hypertension were obtained. History of previous pregnancies including birth weight of previous babies, perinatal deaths, and mode of delivery were elicited. Details of present pregnancy were asked, including the date of last menstrual period, details of scan in the first trimester and clinical examination noting, if available, were scrutinized.

A note was made of the maternal weight, blood pressure and obstetric examination findings of fundal height and various laboratory investigation results. Those with uterine fundal height less than 3cms from the expected height were clinically diagnosed as IUGR and ultra sound examination was done with special emphasis on morphometric measurements. Abdominal

circumference less than 5th percentile and estimated foetal weight less than 10th percentile for that gestational age were selected for study. In cases with risk factors, serial sonography was done to identify fetal growth restriction. Initial dating scan followed by second ultra-sound examination was done at around 34 to 36 weeks.

Patients with irregular cycles, unknown dates, those with restricted growth from the 1st trimester onwards by ultrasound and pelvic examination were excluded from the study group as were those with history of viral exanthematous fever, intake of drugs like antiepileptics, antipsychotics & anticoagulants.

All these cases were kept under surveillance till confinement. A careful search for causes of IUGR like Smoking, Alcoholism and Hypertension were made. Anemia, if present, was corrected and PIH, if detected, was managed appropriately. The cases were monitored by Fetal Kick Count, Cardiotocography, Serial measurements of fetometry AFI and Doppler studies. Doppler studies were done on Umbilical artery, Middle Cerebral Artery and Ductus venosus with a real time color Doppler ultra sound machine. Umbilical cord was located in the pool of amniotic fluid and values were taken at mid cord or placental insertion. Middle cerebral artery was localized in transverse section of fetal skull, at the level of thalamus in the Sylvian fissure. The ductus venosus was sampled in the abdominal circumference section, where it joins the umbilical vein to IVC. The Doppler transducer was placed on the abdominal wall over the uterus and carefully manipulated till Doppler signals appropriate for those particular vessels were identified.

The signals were recorded for a minimum of 5 to 8 cycles with blood flow velocity waveforms of equal shape and amplitude and of satisfactory quality were obtained. The image was frozen and measurements taken. Doppler was considered as abnormal when there was absent or reverse diastolic flow in umbilical artery or PI values were above the 95th percentile for that gestational age. Cerebro placental ratio less than one was also taken as abnormal.

Those cases where fetal assessment was normal were monitored fortnightly till delivery. Those with absent and reverse flow were taken up for termination of pregnancy. In those cases with low diastolic flow in umbilical artery, where fetal maturity adequate for survival was present, the pregnancy was terminated. In cases where fetal maturity was not reached monitoring was done with NST and BPP daily or twice weekly depending upon the severity of abnormality and associated complications. Pregnancy was terminated when there were abnormal readings from CTG or a low score on the bio-physical profile. In those cases where differential shunting of blood flow to fetal brain was present, termination was done even before NST or BPP were found to be abnormal. Mode of delivery was planned depending on the weight and gestational age and amount of liquor present. Outcome of pregnancy was recorded in detail including intrauterine demise, neonatal death, birth weight, Apgar score, development of neonatal complications and presence of congenital anomalies, placental weight and pathology. These details were entered in a proforma and the data was statistically analyzed and evaluated.

Procedure of Obstetric ultrasound examination and Doppler evaluation performed are given below.

FETOMETRY

Biparietal Diameter

Measurement was performed from the outer edge of skull on the proximal surface, to the inner edge of skull on the distal surface in a section that included the midline echo with the cavum septum pellucidum in the anterior third and the thalami on either side. During the study, care was taken to apply minimal pressure to the maternal abdomen with the transducer as the fetal head compression is associated with alterations of intra-cranial arterial flow velocity waveforms (Vyas et al 1990)[68].

Head Circumference

It was measured at the same level as the BPD using the method of expanding ellipse.

Femur Length

A section showing both ends of the femur clearly was obtained and measurement of diaphysis was performed.

Abdominal circumference

A cross sectional view of the fetal abdomen showing the intrahepatic portion of umbilical vein in the anterior third of the abdominal circumference was used for measurement of abdominal circumference by the expanding ellipse method.

DOPPLER EVALUATION

Umbilical Artery

A loop of umbilical cord close to the placenta was located. The segment of umbilical cord was elongated so that the two umbilical arteries and one umbilical vein could be distinguished. Angle of insonation was adjusted to less than 60 degrees. An optimum Doppler signal was obtained and the pulsatility index was measured.

	PI
28 Weeks	**1.2**
40 Weeks	**1.1**

Foetal Middle Cerebral Artery

Section of foetal head used for BPD measurement was obtained and then the transducer was angled caudally till the middle cerebral artery was seen coursing along the sphenoid wings. Sample volume size and angle of insonation were adjusted after placing the cursor in the artery and appropriate signals obtained. The pulsatility index was measured.

	PI
28 Weeks	**2.1**
40 Weeks	**1.5**

In FGR, the expected abnormal findings would be an increased diastolic flow due to the cephalisation of blood flow and brain sparing effect. This would reflect as a decrease in PI values.

Foetal ductus venosus

A transverse section of the fetal abdomen was obtained with the transducer angled slightly cephalad, color flow switched on and the aliasing signal in the ductus venosus identified where it connects the umbilical vein to the IVC.

The sample volume and the angle of insonation were set and the waveform obtained. The PI was then measured.

	PI
28 Weeks	**1.1**
40 Weeks	**0.8**

OBSERVATIONS

The study was conducted on 200 third trimester women with ultrasonologically confirmed IUGR cases and the following observations were made.

Among the 200 cases that were confirmed to be IUGR by B-Mode Ultrasound, 179 cases showed abnormalities in the Doppler wave forms. 21 cases revealed normal Doppler wave forms.

Table No.1

Total No of IUGR Cases	**200**	**%**
Normal Doppler	21	10.5
Abnormal Doppler	179	89.5

GRADING OF DOPPLER ABNORMALITIES

According to the increasing severity of altered Doppler indices in the 200 IUGR cases, we categorized the cases into six from grade 0 (normal Doppler) to grade 5.

Table showing details of Doppler abnormalities

Table No. 2

GRADES		No	%
0	Normal doppler	21	10.5
1	Increased Umbilical Artery PI alone	38	19
2	Cerebroplacental Ratio < 1	93	46.5
3	Absent/reversed EDF in Umb Ar with decreased MCA PI	19	9.5
4	Absent/reversed EDF in Umb Ar with increased MCA PI	23	11.5
5	Ductus venosus alteration	6	3

Out of the 179 cases, 48 cases showed absent/reversed diastolic flow in umbilical artery, out of which 19 had compensated MCA flow while 23 had gone in for decompensated MCA flow (hypoxic and decompensated fetus) and 6 had associated DV abnormalities (acidotic) 38 cases showed only low diastolic flow in umbilical artery, 93 cases showed low diastolic flow in umbilical artery and increased diastolic flow in middle cerebral artery (hypoxic and compensated fetus).

Representative normal and abnormal tracings from the study are shown on plates attached.

AGE DISTRIBUTION

The age distribution of the patients in our study is shown in the following table.

Table No. 3

AGE GROUP YEARS	NO OF PATIENTS	PERCENTAGE (%)
18-22	61	30.5
23-27	93	46.5
28-31	40	20
32-36	5	2.5
> 36	1	0.5

Most of the patients were in the age group of 23-27 yrs.

GRAVIDITY

This table shows the gravidity of the patients in our study group.

Table No. 4

GRAVIDITY	NUMBER OF PATIENTS	PERCENTAGE (%)
PRIMI	108	54
SECOND	51	25.5
THIRD	34	17
FOURTH AND MORE	7	3.5

Majority of our patients were primigravidae (54%).

GESTATIONAL AGE

The distribution of gestational age at which Doppler analysis was done in the study group is shown in the table below.

Table No. 5

GESTATIONAL AGE(WEEKS)	NUMBER OF PATIENTS GRADE						
	0	1	2	3	4	5	TOTAL
34-36	0	0	0	0	0	5	5 **[2 %]**
36-37	2	5	17	11	13	1	49 **[24%]**
37-38	1	3	26	6	6	0	42 **[21%]**
38-39	7	16	25	2	3	0	53 **[26 %]**
39-40	10	12	24	0	0	0	46 **[23%]**
> 40	1	2	2	0	0	0	5 **[2%]**

Most of our patients with mild Doppler abnormalities were adequately monitored till term or even beyond. Patients with higher grades of Doppler abnormalities were induced earlier based on their biophysical profile, non stress test and liquor status for best fetal outcome.

RISK FACTORS

This table shows the distribution of risk factors in the study group..

Table No. 6

RISK FACTOR	NO. OF PATIENTS	PERCENTAGE (%)
Preeclampsia	67	33.5
Gest. Diabetes	5	2.5
Heart disease	6	3
Epilepsy	5	2.5
Others	48	24
None	102	51

67(33.5%) of them had pregnancy induced hypertension as the risk factor. In 5cases (2.5%)gestational diabetes was the identified risk factor.6 cases(3%) had heart disease complicating pregnancy. 48 cases (24 %) had one of the other risk factors like breech, postdatism, bronchial asthma, anaemia, hypothyroidism or chronic hepatitis. 102 patients(54%) had no risk factors

MODE OF DELIVERY

Table showing mode of delivery

Table NO. 7

MODE OF DELIVERY	DOPPLER GRADE 0	1	2	3	4	5	TOTAL
Spontaneous labour (Vaginal)	9	18	32	0	0	0	59 **[29. 5%]**
Induced labour (Vaginal)	8	7	18	8	11	5	57 **[28. 5%]**
Cesarean section	4	13	43	11	12	1	84 **[42%]**

The table shows that mothers of small for gestational age babies with abnormal umbilical artery Doppler studies needed a cesarean section for fetal distress more than the normal Doppler group. In those cases with absent and reverse end diastolic flow in umbilical artery, the labour was induced after counseling the parents regarding prognosis of the baby and in some cases labour was induced for maternal indications like severe preeclampsia.

Out of the 84 patients who had caesarean delivery 4 had elective LSCS and 8 were induced with the aim of vaginal delivery, but taken up for emergency LSCS due to fetal distress. The other 72 patients had LSCS for various indications.

PERINATAL OUTCOME

Table showing perinatal outcome

Table No. 8

PERINATAL OUTCOME	NUMBER OF PATIENTS GRADE 0	1	2	3	4	5	TOTAL
IUD	0	0	0	0	2 **[9%]**	3 **[50%]**	5 **[3%]**
Stillborn	0	0	0	0	2 **[9%]**	0	2 **[1%]**
NND	0	1 **[3%]**	0	3 **[16%]**	17 **[74%]**	3 **[50%]**	24 **[12%]**
Increased Perinatal Morbidity	0	0	15 **[16%]**	15 **[79%]**	2 **[9%]**	0	32 **[16%]**
No significant adverse outcome	21 **[100%]**	37 **[97%]**	78 **[84%]**	1 **[5 %]**	0	0	137**[68 %]**

Out of the 200 cases, 169 were live born and 24 were neonatal deaths. There were 5 cases of intrauterine deaths of the fetuses and 2 were still born. Out of the live borns, 32 had increased perinatal morbidity characterized by poor apgar scores, development of necrotizing enterocolitis, hypoxic ischemic encephalopathy (HIE), meconium aspiration syndrome (MAS), hyperbilirubinemia and prolonged admission in Neonatal Intensive Care Unit for reasons like sepsis or birth asphyxia.

NEONATAL BIRTH WEIGHT

Table showing distribution of birth weight in the study group

Table No. 9

Birth Weight (kg)	NUMBER OF BABIES GRADE 0	1	2	3	4	5	TOTAL
Less than 1	0	0	0	0	1 [20%]	4 [80%]	5 [2.5%]
1-1.4	0	0	2 [18%]	2 [18%]	7 [63%]	0	11 [5.5%]
1.5-1.9	7 [10.5%]	5 [7.5%]	28 [42%]	12 [18%]	13 [19%]	2 [19%]	67 [33%]
2.0-2.4	13 [12.6%]	29 [29%]	58 [54%]	5 [4.7%]	2 [1.9%]	0	107 [53.5%]
2.5 and more	1[10%]	4 [40%]	5 [50%]	0	0	0	10 [5%]

Most of the babies in the group 0, 1, 2 had a birth weight of 2 to 2.4 kgs. Most of the babies in group 3 and 4 had birth weights ranging from 1.5 to 1.9 kgs. In group5, most babies weighed less than 1 Kg. Perinatal mortality and morbidity was more in cases with low birth weights more so if birth weight was less than 1.5 kgs.

OLIGOHYDRAMNIOS AND NON REASSURING NON STRESS TEST

This table shows the occurence of oligohydramnios and non reassuring NST in patients with abnormal Doppler.

Table No.10

GRADE OF DOPPLER	TOTAL NUMBER PATIENTS	NON REASSURING NST	OLIGOHYDRAMNIOS
0	21	1 (4.76%)	3 (11.1%)
1	38	2 (5.2%)	5 (13.15%)
2	93	14 (15.05%)	47 (50.53%)
3	19	8 (42.10%)	14 (73.68%)
4	23	18 (78.26%)	21 (91.30%)
5	6	5 (83.33%)	6 (100%)

This shows us that increasing grades of Doppler abnormalities also had a higher incidence of other poor prognostic factors like oligohydramnios and non reassuring NST.

DISCUSSION

Fetometry by B-Mode Ultrasound is a reliable method of investigation to distinguish between IUGR and normal fetuses. This is probably because in IUGR fetuses, the earliest feature is reduced growth that is readily assessed by a measurement of abdominal circumference that will show consistently lower values than those expected for the particular gestational age. However the B-Mode ultrasound did not reliably detect the adverse perinatal outcome.

Predictive capability of Doppler of adverse outcome in USG confirmed IUGR cases, was analyzed.

Table NO. 11

	Perinatal Outcome		
	Adverse	**Good**	**Total**
Doppler Abnormal	**63**	**116**	**179**
Doppler Normal	**0**	**21**	**21**

Sensitivity of Doppler in predicting adverse perinatal outcome: 100 %

Specificity of Doppler in predicting adverse perinatal outcome: 15.3%

Predictive value of an abnormal Doppler study: 35.19%

Predictive value of a normal Doppler study: 100 %

But on grading the abnormalities from 0 to 5 based on increasing severity of altered Doppler indices, we got the following statistics:

Grade 0 – had a negative predictive value of 100%

Grade 1 – also had a negative predictive value of 100% and that one neonatal death in this grade was due to an unrelated cause namely hand prolapse.

Grade 2 – negative predictive value of 84%

Grade 3 – 95% positive predictive value for adverse outcome

Grade 4 – 100% positive predictive value for adverse outcome

Grade 5 -- 100% positive predictive value for adverse outcome

100% mortality rate

We also found that

- The patients who had mild abnormalities on Doppler (Grade 0, 1 and 2), did not have any mortality related to severity of IUGR, nor did they have any significant morbidity.

- There was a significant increase in occurrence of adverse perinatal outcome with increasing severity of Doppler abnormalities (P value 0.001).

- 97.91% of the patients with marked Doppler abnormalities (Grade 3 or more), had adverse perinatal outcome, compared to 10% of those with mild Doppler abnormalities (Grade 0, 1 and 2).This again was significant (P value 0.001).

- There was a significant increase in perinatal mortality with increasing grades of Doppler (including intrauterine demise, neonatal deaths and stillbirths), with a P value of 0.001.All the cases with intra- uterine demise and stillbirths as also 23 out of 24 neonatal deaths all had grade 3 or more Doppler abnormalities.

- There was also a significant rise in perinatal morbidity with increasing grades of Doppler (P value 0.001)

These observations show us that Doppler can accurately prognosticate IUGR cases and can help in optimizing the time of intervention in a hypoxic fetus.

Among the 200 USG confirmed IUGR cases, 179 cases revealed Doppler abnormalities (89.5%).21 cases revealed normal Doppler findings. No adverse perinatal outcome was observed in these cases. It means that if the Doppler is normal, in an IUGR case, the possibility of an abnormal perinatal outcome is very rare. The normal Doppler result has more importance than an abnormal Doppler result.

Newham et al[69] evaluated the efficacy of Doppler flow velocity waveform analysis as a screening test in pregnancy. They found that prediction of fetal hypoxia by Doppler analysis was enhanced in IUGR fetuses, where it was weak when umbilical artery PI values were evaluated as primary screening tests for fetal hypoxia. These findings very much conform to our observations.

The explanation for these observations is probably that fetal growth retardation can be either due to low intrinsic growth potential or due to defective placental nutritive and circulatory functions, of which Doppler can investigate only the circulatory component.

GESTATIONAL AGE

All the IUGR cases in our study were 34 weeks or more by gestational age. This is explained by 2 reasons:

1. Patients who were diagnosed to have IUGR at peripheral hospitals were referred late for delivery and NICU (Neonatal Intensive Care Unit)care, by which time they had an advanced gestational age, and sometimes marked and severe Doppler abnormalities, which had a poor fetal outcome.

2. Patients with preterm IUGR were not included in the study. This was done to eliminate the added risk of prematurity on the perinatal outcome of these IUGR babies. (i.e.) A baby which may have only a mild growth restriction as evidenced by Doppler, if delivered prematurely due to causes unrelated to the growth restriction, may have an adverse perinatal outcome by virtue of its extreme prematurity, which can actually lead to false negative results for the doppler test.

3. In a patient who has been booked and monitored regularly, we find that each baby has its own growth profile which becomes established only around 24-26 weeks. Thus, a deviation from this growth profile resulting in growth retardation is effectively detectable only after 28 weeks. This was in agreement with the report of Harold Schulman et al in which the most reliable time to screen for IUGR is described as after 24-26 weeks. These patients are also delivered before the Doppler indices worsen, to ensure that the baby has the best chances of survival.

RISK FACTORS

In our study, among the cases that had identified risk factors, the majority had hypertension as the risk factor (33.5%). This is explained by the absence of physiological modification of spiral arteries that causes IUGR in hypertensive cases. This observation conformed to the study of Martin et al[70], which reported hypertension as the risk factor of particular importance in IUGR.

Out of the 200 USG confirmed IUGR cases, 21 cases had normal results on Doppler evaluation. All these cases had no increased perinatal complications except for a low birth weight. This might be due to the fact that these cases were only minimally involved and did not progress beyond the phase of decreased growth in the sequence of events of IUGR. The absence of significant redistribution of fetal circulation and hypoxia, as evidenced by normal Doppler evaluation would explain the better perinatal performance of these fetuses. Our observations were in agreement with the study of Benson et al in which all the IUGR fetuses with normal Doppler waveforms were not compromised in utero and were healthy although the biometric measurements were less than normal.

Most of the studies (Fleischer et al[71], Benson et al[72], Ardunini et al[64]) have assessed the predictability of IUGR by Doppler analysis, and have reported the sensitivity varying from 17% to 78%. But we have studied the predictability of adverse perinatal outcome by Doppler analysis. Our study result was comparable to the findings of Brodszki et al[73] (Sensitivity 100% & Specificity 17%).

All the 179 cases with abnormal Doppler waveforms were subsequently analyzed for their outcome. Only 63 of these cases showed some form of increased perinatal complications. The remaining cases showed only low birth weight. Out of the 63 cases, 31 were deaths and 32 had neonatal morbidity.

From these observations, it is clear that regarding outcome of an IUGR case, a negative Doppler evaluation (normal Doppler findings) has a predictive value of 100% i.e., all cases with a negative Doppler evaluation will subsequently have better outcome without grave perinatal complications. A positive Doppler evaluation as such without any grading of the abnormality on the other hand has a predictive value of only 35% i.e., about 35 of 100 cases with an abnormal Doppler test will subsequently have a grave outcome. This study by Sterne et al[74] reported the predictive value of 37% for an abnormal Doppler evaluation in perinatal complications. The predictive value of 35% in our study is comparable.

This shows the necessity for grading of Doppler abnormality to prognosticate IUGR cases accurately.

Grade of Doppler	0	1	2	3	4	5
No adverse perinatal outcome	21	37	78	1	0	0
Adverse perinatal outcome	0	1	15	18	23	6

P Value-0.001

In our study, when the perinatal outcome was analyzed according to the grades of Doppler abnormality as in the above table, it was obvious that there was a significant increase in occurrence of adverse perinatal outcome with increasing severity of Doppler abnormalities (P value 0.001).

To facilitate comparison, we grouped the patients into 2 groups-Those with mild Doppler abnormalities (Grade 0, 1 and 2) and those with marked Doppler abnormalities (Grade 3, 4 and 5).Perinatal outcome was compared in both groups.

	Mild Doppler Abnormalities	**Marked Doppler Abnormalities**	**Total No. of patients**
Number of patients	152	48	200
Number of patients with adverse	16 [10.5%]	47 [97.91%]	63 [31.5%]
IUD	0	5	5
STILL BIRTH	0	2	2
NND	1	23	24
Perinatal morbidity	15	17	32

From this table, we see that 97.91% of the patients with marked Doppler abnormalities (Grade 3 or more) had adverse perinatal outcome, compared to 10% of those with mild Doppler abnormalities (Grade 0, 1 and 2).This again was statistically significant (P value 0.001).

This is reinforced by the fact that out of 63 patients who had adverse perinatal outcome, 47(74.6%) were from the group with marked abnormalities on Doppler and 25.39% were from the mild abnormalities group (i.e.) a statistically significant group of those with adverse perinatal outcome had higher grades of Doppler abnormalities.X2-15.88(P Value-0.001).

The perinatal mortality rate in our study was 38%which is comparable to a study by Trudinger et al[75] who reported perinatal mortality of 20% in cases with abnormal Doppler analysis.

When we analyze the neonatal deaths, 23 out of 24 deaths occurred in the group with marked Doppler abnormalities (95.83%).The one death that occurred in the group with mild Doppler abnormalities was due to a cause unrelated to the growth restriction-namely hand prolapse with birth asphyxia. This dramatic increase in neonatal deaths with increase in Doppler abnormalities was found to be statistically significant(X2-110.6 P Value-0.001) .The contributing factors to the neonatal deaths include:

- Hypoxic Ischemic Encephalopathy (50% babies)
- Meconium Aspiration Syndrome (33.3%)
- Necrotizing Enterocolitis (29.16%)
- Neonatal Sepsis (16%)
- Hyperbilirubinemia (4%)

More than one cause was responsible in 15 babies.

All the patients, who had intrauterine demise or stillbirths, had marked Doppler abnormalities and this was found to be statistically significant(X2 –15.55 P Value-0.001).

When we analyzed the perinatal morbidity rates, 17 patients out of 32 (53.12%) had marked Doppler abnormalities and 15 (46.87%) had mild Doppler abnormalities. This rise of perinatal morbidity with increasing grades of Doppler abnormalities was found to be statistically significant(X2 –26.56 P Value –0.001)

Perinatal morbidity	**Doppler abnormalities**		**Total no. Of patients**
	mild	**moderate**	
APGAR< 7 AT 5 MINUTES	4	6	10
HIE	0	3	3
MAS	5	1	6
HYPER BILIRUBINEMIA	1	2	3
Prolonged NICU admission (> 1 week)	5	4	9
NEC	1	2	3

- 10 babies had low APGAR at 5 minutes
- 9 babies had prolonged NICU admissions due to reasons like sepsis, severe birth asphyxia
- 6 babies had Meconium Aspiration Syndrome

- 3 babies had Hypoxic Ischaemic Encephalopathy
- 3 babies had Necrotizing enterocolitis
- 3 babies had hyperbilirubinemia

Some babies had more than one of these factors. All these babies had some morbidity which could be reliably predicted by the grade of Doppler abnormalities (P value 0.001)

In our study, when the Doppler abnormalities were analyzed for their severity, it was obvious that all cases with a severe grade of abnormality had a worse outcome, as compared to the rest of cases with a lesser grade of abnormality. The grades 0 to 5, according to increasing severity were of accurate prognostic significance.

Grade 0 - had a negative predictive value of 100%

Grade 1 - also had a negative predictive value of 100% and that one neonatal death was due to an unrelated cause, namely hand prolapse

Grade 2 - negative predictive value of 84%

Grade 3 - 95% positive predictive value for adverse outcome

Grade 4 - 100% positive predictive value for adverse outcome

Grade 5 - 100% positive predictive value for adverse outcome 100% mortality rate

This clearly shows the importance of grading- while grades 0 to 2 have a high negative predictive value for adverse outcome, grades 3, 4 & 5 have a high positive predictive value for adverse outcome and grade 5 actually had a 100% mortality rate.

Some of the other observations made in our study were

- Small for gestational age babies with abnormal umbilical artery wave forms were at an increased risk for oligohydramnios than those with normal Doppler and they also had a higher incidence of non reassuring non stress tests.

- Small for gestational age babies with abnormal umbilical artery velocity wave forms were induced earlier than those with normal Doppler cases.

- Small for gestational age babies with abnormal Doppler were more frequently delivered by cesarean section because of fetal distress

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SUMMARY

- Diagnosis of IUGR was done by clinical assessment and serial sonography.
- The routine use of SFH measurement together with the use of serial ultrasound examinations in the 3rd trimester of high risk pregnancies detected majority of IUGR cases.
- With the use of Doppler of umbilical and middle cerebral arteries, it is possible to predict that an IUGR fetus is not hypoxic.
- With ductus venosus alteration, detection of fetal acidemia is possible.
- Negative predictive value of normal Doppler is 100%. It means that if the Doppler is normal in an IUGR fetus the possibility of an abnormal perinatal outcome is very rare. So, unnecessary intervention can be reduced in those pregnancies with normal Doppler and normal amniotic fluid volume.
- There is a strict co-relation between abnormal umbilical Doppler velocimetry and an increased incidence of perinatal complications in an IUGR fetus.
- Incidence of perinatal mortality and morbidity are increased with the worsening of Doppler velocimetry.
- In cases with absent and reversed diastolic flow in umbilical artery the perinatal morbidity is nearly100%.

- The perinatal mortality in cases of ductus venosus alteration is 100%.
- In cases with differential shunting of blood flow to the fetal brain, frequent monitoring and early delivery should be done.
- The Doppler ultrasound finding of increased resistance of umbilical artery and decreased resistance of middle cerebral artery, detects the fetus at risk of complications 2 weeks earlier than the conventional methods like NST.
- After identifying those fetuses at risk of complications, close monitoring is done by non stress test and bio-physical scoring for planning the delivery so as to improve the perinatal outcome.
- Since ductus venosus has been shown to cause irreversible fetal compromise and inevitably leads to fetal demise, close monitoring should be done so as to deliver before the fetus becomes acidotic which is shown by the increase in ductus PI values.

CONCLUSIONS

- The diagnosis of utero-placental insufficiency causing fetal growth restriction identifies a group of fetuses who are prone for perinatal complications.

- Many fetuses with FGR are hypoxemic and some are acidemic even prior to the onset of labor.

- The role of antenatal surveillance is identification of the hyproxemic fetus, since the sequelae of hypoxemia can only be altered by iatrogenic intervention. Delivery is timed to precede acidemia.

- Doppler ultrasound velocimetry is a noninvasive, repeatable and simple method for antepartum fetal surveillance which holds great promise in this area.

- There is a strong correlation between fetal hypoxemia and Doppler measured flow indices of the fetal arterial and venous circulations.

- Grading of the Doppler abnormalities can accurately predict the perinatal outcome of the potentially compromised FGR baby much earlier than NST and thus it can be used as a prognostic tool as proved in our study.

- So, Doppler ultrasound should be used in all patients with fetal growth restriction, to identify impending hypoxia, to optimise the time of delivery, and hence to optimise the perinatal outcome in these patients.

PROFORMA

Name : Age :

Husband's Name : IP No :

Address : Date of Admission:

Date of Delivery:

Date of Discharge:

Socio economic Status : Education:

Obstetric formula : LMP : EDD :

Gynec. History : Age at Menarche :

Menstrual History :

Marital life :

Obstetric History :

Past History:

H/o Hypertension:

H/o Diabetes mellitus:

H/o Bronchial Asthma

H/o Tuberculosis:

H/o Heart Disease:

H/o Renal Disease :

H/o Epilepsy:

H/o Connective Tissue disease:

Abnormalities

Family History	Twinning	:		
	PIH	:		
Personal History:	Smoking	:		
	Alcoholism	:		
Drug History:				
General condition:	Build	:	Nourishment	:
	Height	:	Weight	:
	Pallor	:	Clubbing	:
	Jaundice	:	Pedal Edema	:
	Cyanosis	:	Lymphadenopathy:	
Vitals:	Temperature:		Respiratory rate:	
	Pulse Rate		Blood Pressure	:
Cardiovascular System:				
Respiratory System	:			
Thyroid	:	Breast:		
Per Abdomen	:			
Investigations:				
HB%	:		PCV	:
Platelets	:		Urine: Alb	:
B1 Sugar	:		Sugar	:
B1. Urea	:		Micro	:
S. Creatinine	:		C & S	:
S. Uric Acid	:			
VDRL	:		Stool: OVA:	
B1. Group and Type	:		Cysts	:
Ultra Sound	:			
Early Scan	:		Serial Scan	:

Presentation			
BPD			
AC			
FL			
HC/AC			
EF.Wt			
CGA			
Placental Position & Grade			
AFI			
Cong. Anomalies			

Provisional Diagnosis :

Colour Doppler :

Umbilical artery PI :

Middle cerebral artery PI :

Ductus venosus PI :

Impression :

Mode of Delivery :

Apgar score :

Birth Weight :

Placental weight and abnormalities:

Neonatal Complications:

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ABBREVIATIONS

IUGR	:	Intrauterine growth restriction
SGA	:	Small for gestational age
CTG	:	Cardio Tocography
NST	:	Non stress test
Umb. Ar	:	Umbilical Artery
MCA	:	Middle cerebral artery
DV	:	Ductus venosus
USG	:	Ultrasonogram
PI	:	Pulsatility index
RI	:	Resistance index
SFH	:	Symphysio - fundal height
NICU	:	Neonatal Intensive Care Unit
MAS	:	Meconium Aspiration Syndrome
NEC	:	Necrotising Enterocolitis
AEDF	:	Absent end Diastolic flow
REDF	:	Reversed end Diastolic flow
LSCS	:	Lower segment caesarean section